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CONTENTS

Phytopathological work in the tropics ..... JOHN R. JOHNSTON 381
A method to induce sporulation in cultures of Botryosphaeria berengeriana ..... J. MATZ 387
A Melanconium parasitic on the tomato ..... W. H. TISDALE 390
A parasitic saccharomycete of the tomato ..... ALBERT SCHNEIDER 395
The longevity of Bacillus amylovorus under field conditions ..... J. W. HOTSON 400
Reviews 409
Phytopathological notes 411
Literature on American plant diseases 415

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PHYTOPATHOLOGY

VOLUME VI NUMBER 5

OCTOBER, 1916

PHYTOPATHOLOGICAL WORK IN THE TROPICS

JOHN R. JOHNSTON

No one who has attempted phytopathological work in the Tropics will object to the statement that there are serious problems in those countries, but as, at the same time, someone may claim that in temperate climates also this subject presents some problems, it will be well to justify with rather full explanations special interest in the problems of the warm climates.

Tropical America is a most heterogeneous assemblage of countries, many of which are widely separated from one another, and have poor and slow means of communication To illustrate this, the Cuban Experiment Station is two full days from the nearest experiment station at Gainesville, Florida and three days from Washington. It is three days from the nearest station to the south at Kingston, Jamaica, and owing to quarantine troubles six days are often required to make the trip. To the east there is nothing in Santo Domingo nor Haiti, and it is five days to Porto Rico. From Cuba to Trinidad is more or less a matter of two weeks—and one would be fortunate to make it in that time.

The central American countries are about as close together as they can be arranged and so is northern South America, but to travel from part of one country to part of another may be a matter of weeks. Modern travel facilities have not yet penetrated all parts of tropical America.

This isolation of pathologists in the Tropics makes correspondence slow and almost prevents personal visits. Association with co-workers from adjacent countries including those in the north becomes an annual event, at least if one is fortunate. This isolation is bad for the pathologist and bad for the work.

There are not many pathological laboratories in the Tropics; they may easily be enumerated: in Surinam, Demerara, Trinidad, Barbados, Porto Rico (2), Jamaica, Cuba (1 private), Costa Rica (private), and in Mexico; this last being practically out of commission at present.

The equipment of these laboratories deteriorates faster than in the North, owing to the moister climate. Few of the present laboratories that have ever succeeded in obtaining good equipment have been able to get it replaced. Specimens to be of any value must be kept in dry, insect-proof cases, which are scarce in the Tropics. In wooden cases the white ants play havoc, and molds render confusion among specimens.

Buildings in the Tropics cannot be closed as in the North, so that it is impossible to keep out many insects, birds and bats. In one of the best furnished laboratories in the Tropics there is a constant fight against big cockroaches and rats. The writer has had rats remove cotton plugs from flask and tube cultures for the purpose of building nests. One well-known laboratory harbors great numbers of nesting swallows, apparently innumerable bats, rats, white ants and silverfish, so that the daily sweepings in this place usually fill several buckets.

So far as literature is concerned for reference to pathological work, the most useful collections that the writer has seen in these countries were the private property of the pathological workers. Sets of Saccardo's *Sylloge Fungorum* are seldom to be found in the laboratories. There is none at either of the two Stations in Porto Rico and none in Cuba. As a consequence, very little taxonomic work is done in the Tropics. The British men send their material to England and the Americans to the States. Occasionally determinations can be obtained in a few weeks, and just as often from four to six years are required.

Even with these conditions, good work is possible in the Tropics, as is shown by some of the publications, but it is a difficult task.

These conditions are accentuated by the restrictions of work to single countries. It is rarely the case that a tropical pathologist studies a disease outside his own country. He is employed by one government to study disease and naturally he is not supposed to be wandering off to the domains of another. It is not considered that many fungi do not appear constantly in the same place. Work on one fungus may be begun and then owing to seasonal changes may have to stop until the next year, or just as likely until the fungus appears the second year afterwards. Again reports may come that certain diseases do not exist in the country, and the following season a fungous parasite may develop as though it were an old resident.

This same variation in the development may cause a pathologist to report a fungus as a harmless, weak parasite, while in an adjacent country apparently the same fungus is damaging the crops and it may as likely as not turn out that the man in the former country will have to change his mind the second season.

As a consequence of this restriction of pathological activities and varia-

tions in conditions, we see pathologists in different countries working on much the same thing and apparently obtaining different results. Several pathologists have investigated the Panama disease of bananas and many years have been spent on it; much work has been done on a similar disease in Surinam, in Trinidad, in Porto Rico, in Jamaica, in Cuba, and by Washington workers also. Still the question is unsettled and different opinions are held as to the cause of the disease. The coconut diseases have served as a bone of contention for many years and the diseases of sugar cane have furnished us with much contradictory literature. The cacao diseases have received attention in various colonies, but there is no unanimity of opinion as to their cause.

The immense duplication of work is desirable—but only theoretically. It is desirable in the States, but not here—at least not to such an extent. As it exists at present, it is an enormous waster of energy, time, and money for the individual pathologist and for the government employing him.

Without exception, it appears to have been true that each one of the twelve or more men who have studied the Panama banana disease in the American Tropics has had to spend time getting acquainted with various phases of the disease and with the crop, and has performed similar preliminary experiments, and not one of them has been in a position to work to a satisfactory conclusion.

Pathological work in the Tropics is often spasmodic, erratic, and temporary; in Demerara little work has been done in phytopathology; in Barbados a great deal of good work has been done in spite of the fact that the pathologists have seldom been able to devote much time to it; in Trinidad much good work has been done by the present mycologist who has probably remained in his position longer than any other pathologist in the Tropics; in Porto Rico some good work has been done in spite of the changes; and in Jamaica and Cuba there has been good work. Withal, sometime we may expect to see some of the more serious diseases relegated to the painful memories of the past, but accomplishments will be at a great cost and with a great waste.

This utterly fails to give a conception of what might have been done under other circumstances with the same men. Most of the men have had short careers in any one position, a condition that has often resulted well for the men, but very poorly for the work. A period of one or two years is of some service in making disease surveys, but it is often of little value in solving strictly pathological problems. Some inoculation experiments and most control experiments require from four to six years for satisfactory results. And when control means securing disease-resistant varieties, ten years is a short time. Needless to say the term "disease-

resistant varieties" is more a figure of speech than a reality in the Tropics.

There are various reasons for the constant passing of pathologists in the Tropics. Perhaps it is sufficient to say that they change because they secure better positions. That a change is made in pathologists at any Station is a more serious proposition in the Tropics than in the North. The work of one or more years is left uncompleted, notes are lost, the new man must acclimatize himself, must learn the people (whether English-speaking or not), must learn the language, learn new crops and new diseases. Many times investigations that were begun are dropped, and others are taken up by the new man only to be left uncompleted when he goes. In other words, there are few people in the Tropics, in any position to assume authority, who have any permanent interest in problems which the Agricultural Stations are supposed to be solving.

Experiments have shown that rigid exclusion of diseased plants from disease-free territory is a practical proposition. Thus in the case of the banana disease or coconut disease let us prevent it spreading into territory where the disease does not occur. Let us go further and destroy what disease we have, and prevent the introduction of more. Thus we can now safely grow crops where before it was a difficult or impossible thing.

On many of the English islands the administration has been far-sighted enough to provide for plant inspection service. In Jamaica the banana disease, among others, is declared infectious and subject to treatment according to law. Any diseased plants found by the inspectors or anyone else are reported and destroyed, so that the disease may not be transmitted to other properties. In Jamaica and Trinidad it is the business of these inspectors to attend to such matters. In most other places diseases come and go without hindrance, great havoc results and the planter looks on helpless to prevent.

An inspection service does not exist in Santo Domingo, Haiti, Porto Rico, none of the Central American countries, nor the countries of northern South America. In Cuba at present there are districts free from the coconut budrot and from the banana disease. So far as the planters are concerned, it may happen any time that these disease-free areas may become infected. In parts of Honduras and the rest of Central America, the banana disease is progressing with the development of the industry.

Not only plant inspection in the individual countries is lacking, but quarantine laws also are wanting. There are, to be sure, such laws in some of the countries, but in many of them they are not enforced intelligently. Some countries are fairly strict on shipments to the United States because they are required to be if they wish to continue the trade. At the same time they are almost absolutely indifferent as to what comes

into their own country. They fail to see that unless they succeed in keeping out disease and pests from their own country, the day may come when they will have little to ship to the States.

These then are some of the problems in the phytopathological work in the Tropics; there is a great lack of communication, laboratories are poorly equipped and isolated from centers of information, the investigations have little permanence, there is a great deal of unnecessary duplication of work, there is a great lack of knowledge of varieties of plants to serve as a basis for certain work, there is a lack of plant inspection work, there is a lack of efficiently executed quarantine laws.

Conditions along these lines have improved during the last ten years and are still improving. In order that there should be less waste and that improvements should proceed more rapidly, it is suggested that a central office or bureau be formed, either in connection with some existing institution or entirely independently. Such a bureau should be supported by subscription from those countries interested. It might well have several lines of work, but along phytopathological lines they could well attend to such things as the following:

1. Keep records of all the work that has been done and is being done at all the various Stations.

2. Keep records of all economic plant parasites that occur in Tropical America.

3. In cooperation with, or independent of, local Stations perform lengthy investigations or experiments, as for example, a study of banana varieties and coconut varieties.

4. Make a disease survey of Tropical America.

5. Keep a record of all quarantine and plant inspection laws of the various countries of the Tropics.

6. Publish reports containing (a), miscellaneous mycological and pathological notes; (b), any information along quarantine lines.

To explain these aims more fully, it may be said that the prime purpose of keeping records of the work at the Stations is to prevent the loss of data consequent upon the removal or change of pathologists at Stations.

The object of keeping records of all economic plant parasites is to assist in the knowledge of the distribution of plant diseases and to furnish data for plant quarantine work.

To perform lengthy investigations has a two-fold purpose: first, to eliminate unnecessary duplication of work in the Tropics and second, to furnish data along those extremely important lines that are untouched at present for lack of permanence in the work of any Station. This could well be done in cooperation with existing Stations. For example, cooperation might be arranged with the Experiment Station in Porto Rico to start plantings of varieties of coconuts. This might well last through

the administration of three or four pathologists or horticulturists, during which time notes might be lost unless kept permanently recorded by the Central Bureau.

The disease survey of Tropical America would be simply an extension of the present work that is being conducted by the several Stations. One serious fault with the present work is that many diseases are known in various countries and are never published upon as the pathologists are usually working on special problems. This work would be for purposes of quarantine legislation.

Records of quarantine and plant inspection laws of the various countries would be kept for the convenience of shippers, as it often happens now that consular agents are not as well informed upon these matters as they should be to facilitate shipping.

Publication of reports would be for the purpose of furnishing desirable data along these lines to anyone interested and to furnish a place for recording the occurrence of parasitic fungi, and to spread information as to quarantine measures.

As suggested, such a bureau might well work along several lines, but in phytopathology they would require headquarters in some such city as Washington, where the facilities for consulting the literature are good; for a staff they should have one or more entomologists and pathologists in addition to a recording clerk. The primary work of the staff would be to coordinate the work of the different Stations and to conduct disease and insect surveys. The ultimate aim of the Bureau should be to develop experts on the diseases of different crops. Thus, instead of a dozen men working on the banana disease in their own localities, one or more experts who knew the conditions in all the countries could be called upon for advice.

The success of this plan would depend largely upon the kind of coöperation offered the individual Stations. It is not proposed to supplant them in any particular whatever, but rather to serve as a medium through which their work may be coordinated, to undertake work they cannot do, and to make investigations where no Stations at present exist.

One other thing upon which depends the success of such a plan is the permanence of the institution executing it. One important motive of such an institution would be to secure permanence of work and records and unless the institution were permanent, this important motive would not be fulfilled.

Men fitted to carry on this work are unquestionably scarce. Preferably young men who have an ambition to learn new conditions, new peoples, new languages and new crops, should be selected, and if adaptable men are secured they will in a few years prove the worth of the entire plan.

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A METHOD TO INDUCE SPORULATION IN CULTURES OF BOTRYOSPHÆRIA BERENGERIANA

J. MATZ

WITH ONE FIGURE IN THE TEXT

In working with *Botryosphæria berengeriana* De Not. it was found that it rarely sporulates in pure culture in the ordinary culture tube. This fungus was grown on oat agar, corn meal agar, prune agar, nutrient standard agar, autoclave-sterilized plugs of pecan and oak limbs, and on bean pods. A grayish green mycelium, turning black with age and some scattered stromatic bodies were produced (fig. 1, *B*), but, except in rare instances, no spores of any description were observed on any of the above media used in tubes or in plates.

When bits of Botryosphæria mycelium were inserted into wounds made with a sterile scalpel in healthy pecan twigs, the wounds subsequently being wrapped with paraffined paper, the three forms of spores, i. e., micropycnospores, macropycnospores, and ascospores were produced in varying quantities in the infected tissues (fig. 1, *A*). Reisolations of these gave grayish green mycelia, turning black with age, and some sterile stromata only. Mycelium placed in wounds on healthy pecan wood which was washed in 1 to 1000 bichloride of mercury, rinsed in sterilized water and placed in test tubes did not produce any spores.

Grossenbacher and Duggar[1] in their work with *Botryosphæria Ribis* state the following: "In pure culture this organism has borne out remarkably well its earlier reputation as a "sterile fungus," although on the hosts three conspicuous spore-forms were subsequently obtained, . . . the fungus has been grown on all of the solid media reputed to induce fruiting in culture, and many others; but only various irregular, woolly, stromatic bodies resulted, which in some cases developed perithecial bodies that never produced spores."

After several attempts with various methods at this laboratory, the following method was evolved and found successful: Healthy pecan limbs were cut into plugs about two inches long. These were placed in a glass tumbler filled with a solution of 1 to 1000 bichloride of mercury and

[1] Grossenbacher, J. G., and Duggar, B. M. A contribution to the life-history, parasitism, and biology of Botryosphæria Ribis. New York State Agr. Exp. Sta. Tech. Bul. 18 : 131. 1911.

allowed to stand in the solution ten minutes. The surfaces of these plugs were rubbed to remove air from cracks, then rinsed in sterilized water. The tumbler was left in a horizontal position to allow a thorough removal of the water. After the surfaces of the plugs were sufficiently dry, cuts were made with a sterile scalpel into the bark, and mycelium was inserted into the cuts. By using a hard needle to hold each plug at one end, the plug was plunged for an instant in molten paraffin (60° to 62°C.). In about four weeks numerous stromata were found on the paraffined plugs with pycnidia containing micropycnospores and macropycnospores identical

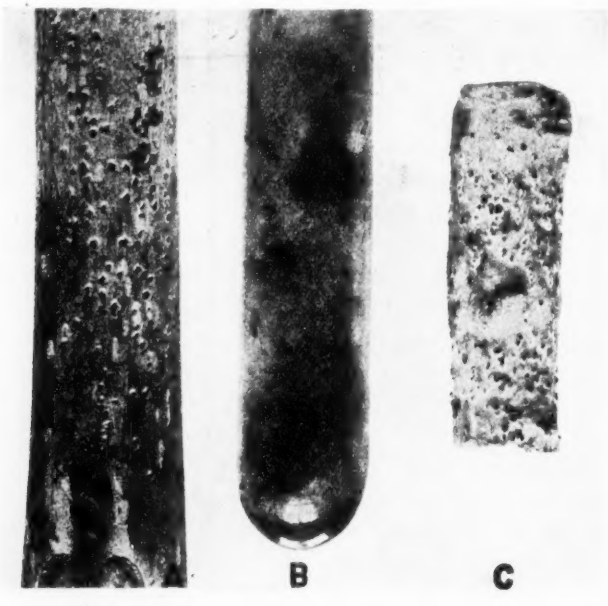

FIG. 1. *A*, Pecan limb artificially infected with *Botryosphæria berengeriana*. Three months from date of inoculation. Mature stromata breaking through epidermis. × 2; *B*, three-weeks-old culture of *Botryosphæria berengeriana* on a steam sterilized bean pod in a tube; *C*, the same fungus on a pecan plug which was sterilized with bichloride of mercury and coated with paraffin. Mature stromata are breaking through the paraffin coat.

with the spores of *Botryosphæria berengeriana* (fig. 1, *C*). No perfect stage of this fungus has so far been observed on paraffined plugs of wood. Mycelium from both perfect and imperfect forms were used in this method with unvarying success in abundant spore-production as described above. The cultures were started from single ascospores; from single macropycnospores (Dothiorella stage), obtained from dead bark of the pecan,

Carya illinoensis; and from bits of pecan wood tissue taken from near a region abundant with stroma containing the Dothiorella stage of the Botryosphæria. It seems that the substitute of a coat of paraffin around the plugs of wood in place of the glass tube eliminates the moist air which ordinarily exists in culture tubes and in this way suppresses the growth of aerial mycelium and induces the formation of mature stromata.

UNIVERSITY OF FLORIDA
EXPERIMENT STATION
GAINESVILLE, FLA.

A MELANCONIUM PARASITIC ON THE TOMATO

W. H. Tisdale

With Three Figures in the Text

INTRODUCTION

A black spotting of tomato fruits in the horticultural greenhouse at the University of Wisconsin was brought to the attention of the writer in January, 1915. About twenty per cent of the fruits in one section of the house were more or less spotted. The disease occurs on fruits at any age and results in considerable damage. Should the trouble become widespread it would likely be of considerable economic importance.

SYMPTOMS OF THE DISEASE

The lesions first become visible on green fruits as irregular, brownish spots, which later become darker in color and finally black. Surrounding the spots, in some cases, there are sunken areas, or slight depressions. The spots are small, seldom reaching an eighth of an inch across. The skin of the ripe fruit may be slightly yellow around the spot but it usually retains its normal color. The line of demarcation between diseased and normal tissue is sharp. The spots may be numerous, and they occur on fruits of all sizes both green and ripe. The central portion of the spot is slightly raised above the surrounding, sunken area in some instances. The diseased tissue is of a tough, corky consistency. The spots, which occur independent of wounds, are confined to the superficial layers of the fruit (fig. 1).

The symptoms of the disease, when produced by artificial wound infection, are considerably different. Sunken areas are produced which are light to dark brown on mature and ripe fruits and black on young fruits. One spot may involve the entire side of a fruit. There is a distinct zonation in most cases, the zonation rings being of a darker color than the diseased area in general (fig. 2). After the spots are ten to twelve days old, yellowish specks, which are rudimentary acervuli, can be seen beneath the epidermis. These push through the cuticle in the form of an erumpent mass of whitish mycelium, which produces a black mass of spores. Spore masses are also produced in the carpellary cavities of the fruit.

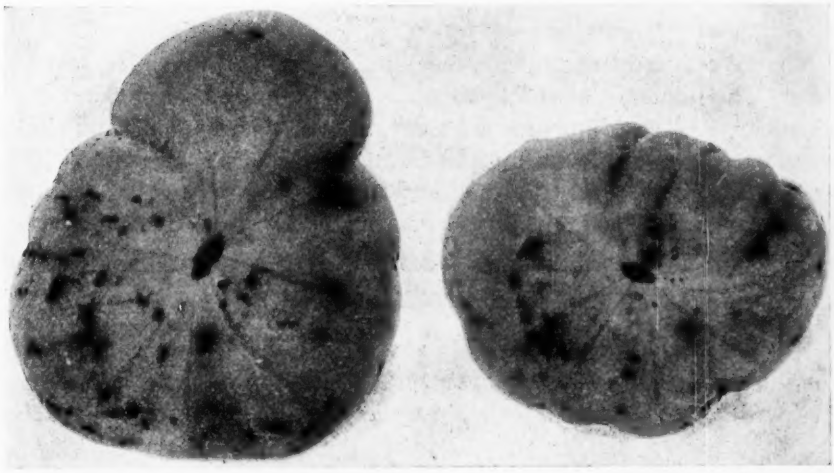

FIG. 1. Two green tomato fruits showing the superficial type of spot as produced by natural infection with Melanconium.

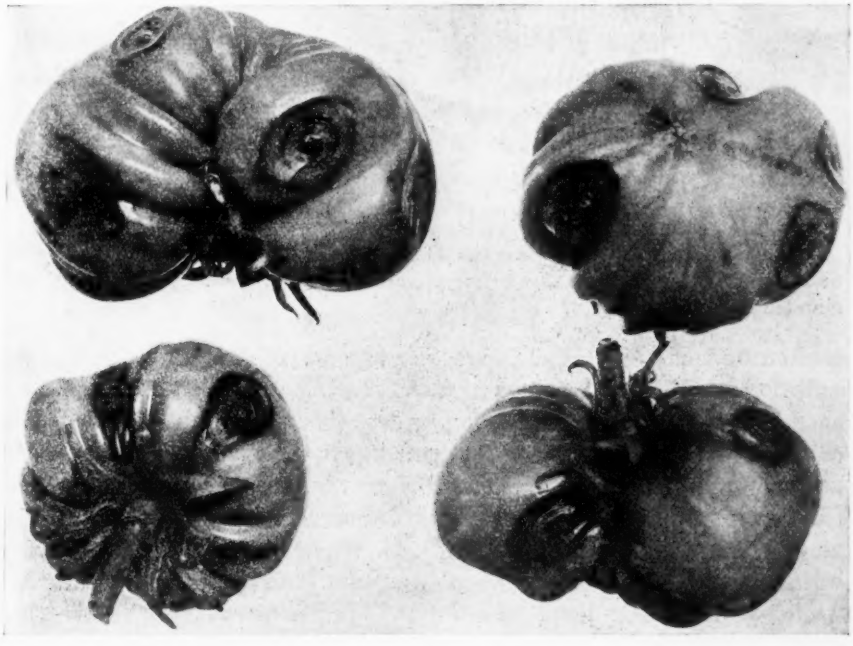

FIG. 2. Four tomato fruits infected by inserting spores of Melanconium into needle punctures. Fruits at any age are readily infected by this method. Notice the sunken type of spot with concentric markings.

THE CAUSAL ORGANISM

The mycelium of the fungus is white or hyaline, branching, and septate. The diameter of the hyphae is fairly uniform, being about three microns. The conidiophores are short, unbranched, hyaline, and closely compacted together in an upright form, producing an acervulus. They arise from a definite basal stroma and produce spores singly at the apex. Conidia are one-celled, cylindrical, with rounded apices, light green when single and black in mass, 2 to 4 by 7 to 10μ. Spores placed in hanging drops of tomato decoction at 23° and 27°C. germinated perfectly in a few hours (fig. 3, *A* and *B*).

A large number of species of Melanconium have been described, which, for the most part, are saprophytic on twigs and the bark of forest trees. The writer has not been able to find any report of the occurrence of Melanconium on tomatoes. The fungus corresponds fairly well, with the descriptions of the genus as given by Saccardo,[1] Engler and Prantl,[2] and Stevens,[3] but varies so widely from other described species in its mycological characters, to say nothing of its parasitic nature, that it appears to be an undescribed species. A Melanconium which is morphologically identical with the tomato parasite was found growing saprophytically on onions in the same greenhouse by J. C. Walker. When green tomatoes were inoculated with this species, or strain, it failed to prove parasitic, while, on the other hand, the tomato organism was very destructive.

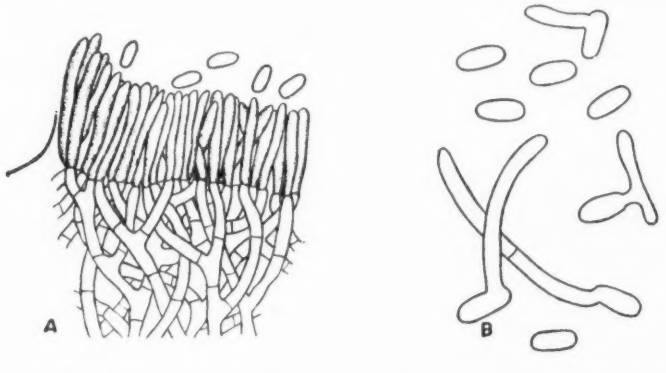

FIG. 3. *A*, Drawing to show the fungal part of an acervulus produced by Melannium on the tomato fruit. From microtome section; *B*, Melanconium spores germinated and ungerminated.

[1] Saccardo P. A. Sylloge fungorum.

[2] Engler, A. and Prantl, K. Die Natürlichen Pflanzenfamilien.

[3] Stevens, F. L. The fungi which cause plant diseases, p. 553–554. 1913.

The author hesitates to burden the genus, which is already extensive, with another binominal. Should the disease become of considerable economic importance, however, it would probably be expedient to apply a specific name.

CULTURE

The fungus is not easily isolated from the superficial type of spot. It was first isolated on oat agar by the fragment-culture method. After isolation the organism grows fairly well on any of the more commonly used media. The superficial mycelium is white and very profuse. On corn-meal agar, however, it becomes greenish gray with age. The black spore-masses are not produced on potato agar to which no dextrose is added. On tomato, oat, and corn-meal agars the spore production is about the same. The spores are produced in disk-like masses which are very black and have a glistening, moist appearance. Very young spore masses are deep grass-green in color. The mycelium holds its uniform diameter on all media used.

INOCULATIONS

The disease was reproduced on both green and ripe fruits on plants in the greenhouse. By spraying with a spore-suspension in water the superficial type of spot was produced. In this case infection was obtained only in those cases where the fruits were wrapped with moist cotton after spraying. The cotton was removed in from one to two days. The wound type of spot (fig. 2) was very easily produced by inserting spores into the fruits by needle pricks. This proved to be a sure way

TABLE 1

Inoculation Experiments

DATE OF INOCULATION	FRUITS INOCULATED	METHOD OF INOCULATION	RESULTS
January 16	5 green	Needle prick	All infected
January 16	3 green	Sprayed and not wrapped	No infection
January 21	3 mature	Sprayed and wrapped	One infected
February 6	7 green	Needle prick	All infected
February 13	12 green	Sprayed and wrapped	Four infected
March 2	3 green	Pricked and sprayed	All infected
March 18	10 green to ripe	Needle prick	All infected
March 27	9 green	Sprayed and wrapped	Four infected. Stem of one fruit attacked
April 5	12 green	Sprayed and wrapped	One infected

of infection. Both types of spot were produced on the same fruit by spraying a cracked fruit with a spore-suspension and wrapping with moist cotton. The wound type of spot was produced where the fruit was cracked and the superficial spots on the uninjured surface. In one case, as will be noted in the preceding table, the stem of a fruit was attacked. The fruit fell and acervuli were produced on the stem. The preceding table shows the results of inoculations.

The results show that the fungus grows very readily on tomato fruits when introduced by wounds. It is also able to attack fruits which are apparently uninjured if the moisture conditions are suitable for germination and growth.

WHITE FLIES AS CARRIERS

One noticeable feature in the greenhouse where the disease first developed was the abundance of white flies. It occurred to the author that these flies were probably carrying the spores of the fungus from plant to plant. There is no reason why this should not be the case as the acervuli break through the cuticle and the spores, which are borne in abundance, are very easily detached. Indications of the disease being spread in this manner were found later in the experimental plot when the white flies got into that section of the greenhouse. In this case the disease soon appeared on wounded fruits where inoculations were not made with the Melanconium.

UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN

A PARASITIC SACCHAROMYCETE OF THE TOMATO

ALBERT SCHNEIDER

WITH FOUR FIGURES IN THE TEXT

The more careful study of food products impelled by the enforcement of the pure food acts, federal as well as state, is revealing some new and interesting problems in cellular biology and in parasitology. We are beginning to get a better insight into the sources of certain food contaminations and deteriorations and the causation of the more important infections of the vegetable as well as animal products employed in the preparation of food materials.

Within recent years the United States Bureau of Chemistry has given considerable attention to the critical examination of tomato products, such as canned tomatoes, catsups, tomato pastes, and those products which contain tomato additions, as soup stocks, pork and beans with tomato, and so forth. The writer has made a microscopic study of the tomato in order to ascertain the normal histologic characters of this fruit. This led to the discovery of the sphaerocytes which have been reported upon elsewhere.[1] It would appear that the sphaerocytes are important factors in the ripening processes of fruits. A voracious yeast devouring ameba of the decaying banana has been described.[2] A heterogamous ameba of the decaying tomato has been noted. A parasitic ciliate has been found in tomatoes imported from Mexico. This ciliate resembled *Leishmania tropica* in its morphological characteristics.

A most interesting organism was recently isolated from tomatoes obtained from a Berkeley, California, restaurant. The restaurant proprietor maintained that the tomatoes came from the South Sea Islands. It is more likely, however, that they came from Mexico or perhaps from Cuba. The organism proved to be a saccharomycetous ascomycete parasitically associated with the ripe tomato. The affected tomato appeared normal excepting an area about two centimeters in diameter which was slightly depressed and of a peculiar dull, reddish brown color. The epidermal tis-

[1] The sphaerocytes of plants and their possible significance in plant growth and in neoplasmic formations. Pacific Pharmacist **9**: 147–155. November, 1915.

Die Blasenzellen der Pflanzen und ihre Bedeutung zur Erklärung Neoplasmischer Bildungen. Deutsch-Amerikanische Apotheker-Zeitung. November, 1915.

[2] The sphaerocytes of plants and the saccharophagous amebas of decaying bananas. Merck's Report. February, 1916.

sue was markedly indurated and somewhat shriveled, but the hypodermal tissue as well as the parenchymatous tissue underneath appeared to be nearly normal. The microscopical examination showed the presence of a fungus in the seed-chamber and in the mucilaginous tissue surrounding the seeds, as well as in the parenchymatous tissue beneath the epidermis.

The affected material proved of special interest because every slide mount examined showed the complete life cycle of the organism, including the formation and development of the highly polymorphic vegetative cells and the various stages of gametic fusion and of ascospore formation, and also the formation of the arthrospores. The vegetative cells multiply by budding as typified by the saccharomycetes generally. The normal vegetative cells may be described as ellipsoid to distinctively ovoid, without vacuoles or recognizable nuclei. The plasmic contents line the inner wall of the cell and accumulate at the poles, usually more abundant at the larger end or at the distal end of the cell in case of cell aggregates. The vegetative cells may, however, undergo remarkable changes in form. They may be greatly elongated and variable in width. Occasionally the elongated cells give a very close resemblance to true hyphal fungi. Occasionally a single cell may become bent or elbowed or narrowed at one end resembling a gourd. Daughter cells are always developed apically, never laterally, as is the rule in the majority of the group Saccharomycetes. The exceptions are the cells which form at the junction of two cells. Daughter-cell formation is usually bipolar, that is, starting with a single vegetative cell, new cells may form from both apices (fig. 1).

The plasmic substance of the cells, inclusive of that of the arthrospores, appears to be homogeneous. On the exterior of this homogeneous, absolutely colorless, plasmic substance there are usually a few comparatively large spherical, colorless, highly refractive granules which are no doubt the true plasmic granules. They measure about 0.5 micron in diameter and are very uniform in size. In the vegetative cells they are very sparingly present, there being from one to three or four. They are more abundant in the arthrospores, from five to as many as one hundred being present. The plasmic granules stain readily. They are slightly actively motile and show remarkable Brownian vibration. No Brownian vibration is noticeable in the granules of the dying or dead cells or spores.

The ascospores are formed in spore sacs which result from the gametic union (isogamous) of two normal, elliptical, vegetative cells. The cell membrane is dissolved at the point of contact. The plasmic contents gather at the contact ends of the gametes and as the membrane is dissolved the plasmic substances of the two cells fuse. The complete changes are shown in figure 3. Eight spores are formed in each spore sac. At an

early period in the development of the spore sac (ascus) the associated vegetative or somatic cells become disconnected and the spore sac exists as an independent cell structure. There are indications that a spore sac may be derived from a single vegetative cell, without gametic fusion of cell plasms; especially does this appear to be the case under conditions of very active ascospore formation.

As a rule, active ascospore formation occurs simultaneously with active arthrospore formation. The end effort appears to be arthrospore formation under conditions unfavorable to the continued existence of the organism. The arthrospores are simply enlarged vegetative cells which take on a spherical form and are remarkable in that they invariably continue to maintain the originally bipolar position in the suspending liquid. Thus, when examined under the compound microscope, it will be found that the nucleus, with the surrounding homogeneous, plasmic substance and the plasmic granules, occupies a lateral position on the inside of the cell so that an edge view is always presented, as indicated in figure 2, *A*. In not a single instance was the spore to be seen in exactly vertical view. Very rarely was the spore sufficiently tilted to present the view shown in figure 2, *A*. The cell-wall becomes thickened and there is an increase in the number of plasmic granules, as already indicated. There is a small group of plasmic granules at the pole opposite the nucleus. While as a rule only one cell of a group of vegetative cells becomes converted into a spore, occasionally two, three or even four such cells in a row become converted into arthrospores. The vegetative cells which do not change into spores soon become dissociated, as in the case of ascospore formation. Occasionally arthrospores take on the gourd form as shown in figure 4.

The ascospores are two-celled, rather slender and taper to a point. The two cells differ materially. The cell which is directed toward the middle of the ascus and which contains the cilium or ligule, stains very heavily. The ligule which is entirely motionless appears to be gelatinous in character and serves the purpose of attaching the spore to its fellows in the group of four, and also to other objects with which the spore may accidently come in contact. There are indications that the chromatin cell of the spore serves as a source of food supply for the vegetative achromatin cell which is concerned in starting a new cycle of cell-formations by budding. The chromatin end of the spore gradually shrinks and the residual or unused portions of the cell contents disintegrate and dissolve in the surrounding medium.

The fungus is a true parasite, as it develops in and upon living tissues and will not develop in the presence of decay. Upon the death of the tomato tissues and the accompanying invasion by the rotting bacteria and molds, this organism at once enters upon very active spore formation,

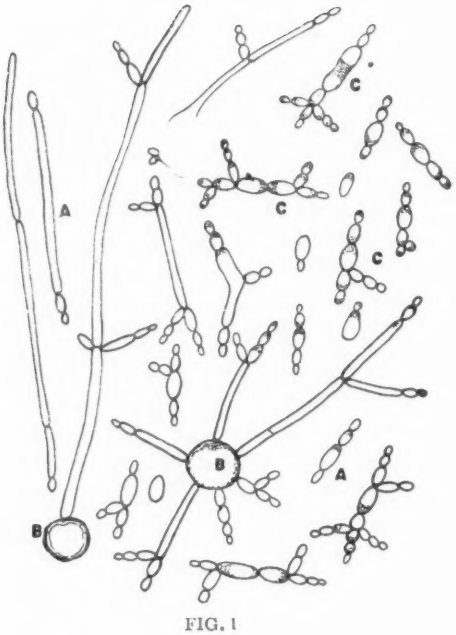

FIG. 1

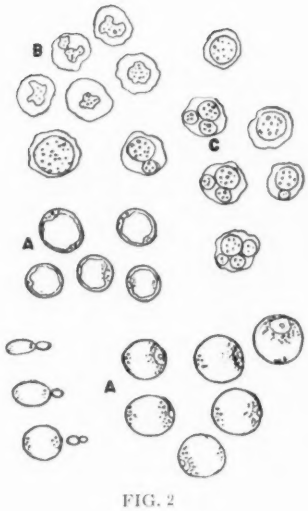

FIG. 2

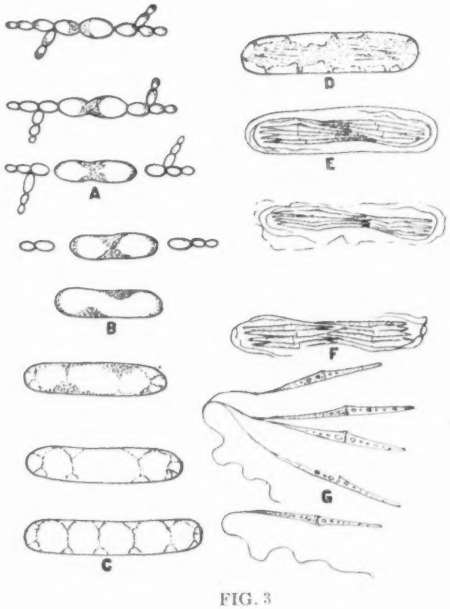

FIG. 3

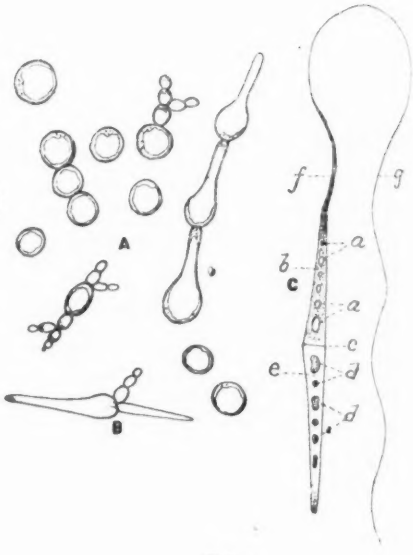

FIG. 4

ascospores as well as arthrospores, and all vegetative cell-formation ceases. The final activity consists in the conversion of the vegetative cells into arthrospores. The cells of the final crop of arthrospores are unusually large and the plasmic granules are increased in number. Death of the arthrospores is frequently preceded by sphaerocyte formation. That is, the plasmic contents of the spore gathers into one or more spheres in the interior of the cell, with the plasmic granules occupying a position within the plasm. Whether these were true sphaerocytes capable of growing and dividing or mere plasmic spherules could not be ascertained. In most instances sphaerocyte-formation was the precursor of the death of the plasm.

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EXPLANATION OF FIGURES

FIG. 1. *A*, Various forms of vegetative cells of the Saccharomycete. Extremes in cell formation are not shown. Very frequently the hyphal filaments resemble the hyphae of a true mold but the individual cells do not branch as in the true molds; *B*, arthrospores; *C*, the beginning of spore sac formation.

FIG. 2. Arthrospore formation. *A*, stages in the formation of arthrospores; *B*, dying spores. The plasmic substance has gathered in the middle of the cell (plasmolyzed); *C*, Sphaerocyte formation within the arthrospore as explained in the text.

FIG. 3. Various stages in the fusion of the plasmic contents of the gametes. *A*, two vegetative or somatic cells unite end to end with solution of the contact cell walls; *B*, the plasmic contents of the gametes fuse; *C*, the fused plasm again becomes septate; *D*, division proceeds to the formation of eight spores forming plasmic masses which soon draw away from the cell wall and gather in the middle of the ascus; *E*, fully formed spores, eight in number; *F*, the ascus membrane soon gelatinizes and dissolves, completely setting free the spores which remain attached to each other in groups of four; *G*, gradually the spores become separated and are distributed through the medium.

FIG. 4. *A*, Arthrospore formation. Ordinary vegetative cells are gradually transformed into spores; *B*, an ascospore beginning a new vegetative cycle; *C*, detailed structure of a mature ascospore highly magnified; *a*, vacuoles in the chromatin cell of the spore; *b*, chromatin substance; *c*, transverse septum; *d*, plasmic masses in the achromatin cell of the spore; *e*, achromatin; *f*, the portion of the filament or ligule which stains very heavily; *g*, the greatly elongated gelatinous filament by means of which the spore attaches itself to various objects with which it is brought in contact. The ascospore is distinctly two-celled. The spore wall as well as the septum are thin. There is a distinct widening of the spore at the transverse septum, *c*.

THE LONGEVITY OF BACILLUS AMYLOVORUS UNDER FIELD CONDITIONS[1]

J. W. Hotson

With Four Figures in the Text

The fire-blight organism has been the object of much observation and experimentation by a large number of investigators in various parts of the country, both in the laboratory and in the field. Among other phases of investigation the length of time the organism may live under different conditions has received some attention. Most of this work has been done in the laboratory with pure cultures of the organism although some attempts have been made to determine the longevity of the Bacillus under field conditions.

In a cultural study of *Bacillus amylovorus* (Burr.) Trev., Stewart[2] has shown that the thermal death-point of this organism is about 47°C. when exposed for ten minutes. He has further shown that when cultures in petri dishes are exposed to direct sunlight for four hours the organisms are killed. Referring to this organism, O'Gara[3] states "It is killed by exposure to direct sunshine in a very few minutes, usually not more than ten minutes unless protected by the bark. . . . . The germs are killed by high temperature. They are wholly destroyed when subjected in a liquid culture to a temperature of 55°C. for ten minutes." These statements which may be perfectly true when taken in connection with the context have misled some of the growers of the Yakima Valley in Washington who argued that if the organisms are killed by the sunlight in four hours or by heat which in the Yakima Valley often reaches 50°C. in the sun, there is no objection to leaving amputated blighted branches under the trees until it is convenient to remove them. Moreover, in the treatment of active cankers, especially those on large limbs, other orchardists grasping at this "light and heat straw" conceived the plan of cutting off the outer protective layer of bark without penetrating as deeply as the cambium. With this outer portion of the bark removed it was believed the sun should kill the organisms left in the inner bark. The advantage of this mode of treatment over the usually accepted method

[1] Abstracted in Phytopath. **6**: 115. 1916.

[2] Stewart, V. B. The fire blight disease in nursery stock. Cornell Univ. Agr. Exp. Sta. Bul. 329: 317–371. 1913.

[3] Lowther, Granville. Encyclopedia of practical horticulture **3**: 1622.

of shaving off the diseased bark down to the sapwood and disinfecting the wound is that, if it is effective, a portion of the cambium will still be left, which will eventually heal over the whole wound. Again, it was argued that if a narrow band of the outer bark is cut off, in the manner just mentioned, above and below an active canker, the organisms will not cross this strip because the sunlight will kill them. In this way the cankers may be prevented from spreading up or down the limb and the organisms may eventually die out

Questions of this nature became of such interest to many of the best growers in the Yakima Valley that numerous experiments bearing on the subject were performed by the writer in an effort to get at the facts in the matter. The object of these experiments was to obtain, if possible, some definite information regarding what actually occurs in the orchard, how long fire-blight organisms live in the dried-up exudate; how long they live in infected branches that are left under the trees, in deep grass, or in clear cultivation; and also the effect of sunlight on the organisms in cankers that have a thin outer layer of the bark removed.

It has already been shown[4] that in the case of the invasion of the leaves by *Bacillus amylovorus* the bacteria apparently soon die, seldom producing "twig infection as a result of the organisms working back through the petiole."

LONGEVITY OF BACILLUS AMYLOVORUS IN AMPUTATED BRANCHES

Fulton[5] has reported some work along this line with the result that, "Out of 35 twigs, 31 twigs, or about nine-tenths were inactive at the end of seven days; and the majority of these had become inactive in three to five days." He concludes that "the quick death of blight bacteria in cut twigs, and the remote chance of their being transferred to living trees, brings in question the necessity for rigid destruction of blighted twigs after their removal." In this account nothing is said as to the size of the "twigs" used but it is inferred that they were small, possibly terminal infections. The writer infers this not only from the use of the word "twig" but because he obtained practically the same results as described by Fulton with small branches of terminal infections and watersprouts.

During the summers of 1914 and 1915 fire-blight was very destructive in the Yakima Valley, Washington, and in some districts the entire apple and pear industry was threatened. In several instances whole orchards looked as if a fire had swept through them turning all the leaves of the terminal

[4] Hotson, J. W. Observations on fire blight in the Yakima Valley, Washington. Phytopath. **6**: 288–292. 1916.

[5] Fulton, H. R. The persistence of Bacillus amylovorus in pruned apple twigs. Phytopath. **1**: 68. 1911.

branches brownish. Amputation of the parts infected, a foot or eighteen inches below the lowest outward evidence of the disease, was the chief remedial measure recommended for twig, blossom, or body infections.

This mode of treatment often necessitated the removal of large limbs, some of which had exudate freely oozing from the diseased bark. This process known as dehorning is illustrated in figure 1, which shows part of a young Spitzenberg orchard. Figure 4 represents a similar condition in an orchard of Bartlett pears. Not infrequently the trunks of trees became infected and it was necessary to remove the entire tree. This condition is shown in figure 2 which is a photograph of a young Spitzenberg apple tree that had been severely pruned in the hope of saving it but in which the disease spread to the trunk, producing an active, exuding canker.

Orchardists often left these large exuding branches on the ground for weeks or even months before removing them. It was only by the constant admonishment of the State Horticultural Department that these pruned branches were burned soon after they were removed from the trees.

It should be remembered that in the Yakima Valley, although the days during the summer are extremely warm the nights with few exceptions are cool, even cold at times. This is particularly true in June when the exudation from infected limbs is at its height. These cool nights are undoubtedly favorable to the growth of the fire-blight organism, since its best growth occurs between 22° and 25° C. with a gradual retardation below this optimum.

Experiment 1

Several branches about four centimeters in diameter, badly infected with blight and exuding freely were brought into the laboratory on June 7. Owing to the writer's absence they were kept standing in a pail of water for a period of ten days. On June 17 one of the branches was placed on a ledge on the southwest corner of the Yakima County court house. In this position it was subjected to the direct sunlight from 5 o'clock in the morning until 7 o'clock at night, with a temperature in the middle of the day ranging from 40° to 50°C. The other branches were left in the laboratory but not in water. Samples were taken every day from the dried exudate on the branches and gross cultures on green pears were made in a manner similar to that previously described.[6] In this experiment a portion of the dry exudate was transferred each day to the aseptic slices of pear. The characteristic milk-white beads of *B. amylovorus* were obtained for ten consecutive days. By that time the dry exudate on the branch was all used and portions of the bark about one centi-

[6] Hotson, J. W. Fire-blight on cherries. Phytopath. **5**: 312–316. 1915.

FIG. 1

FIG. 2

FIG. 3

FIG. 1. A young Spitzenberg orchard that has been "dehorned" in an effort to control fire-blight.

FIG. 2. A four-years-old Spitzenberg tree reinfected after it had been "dehorned".

FIG. 3. A Jonathan apple showing beads of exudate produced by *Bacillus amylovorus*. Photograph made by Henry Schmitz.

meter square, extending to the cambium, were taken as samples. The wounds thus made were immediately covered with soft grafting wax to avoid excessive evaporation at these points. This was continued for several weeks, the typical fire-blight exudate being obtained up to July 5, that is, eighteen days after the experiment began or twenty-eight days after the branch was taken from the tree. The limbs that were kept in the laboratory yielded living organisms up to July 16 or thirty-nine days after they were cut from the tree.

FIG. 4. Pruning Bartlett pear trees that are badly infected with fire-blight.

Experiment 2

On June 29 a pear that had already turned black and hard and with a large bead of exudate on it was exposed to the direct sunlight in the same place as the apple branch mentioned in Experiment 1. When this exudate was transferred to slices of pear in the manner already mentioned, living fire-blight organisms were obtained with the characteristic white beads of exudate on July 12 or after thirteeen days' exposure to the direct sunlight.

Experiment 3

A blighted branch that was exuding freely was exposed to the weather on June 30 in such a position that the direct sunlight was on it about half of each day. During the period of exposure of the branch there were two periods of light rainfall, one of which lasted practically the whole

day, the other occurring at night. Samples of bark about one centimeter square were taken from this branch every two days and treated similarly and with the same care as in Experiment 1. The living organisms were regularly obtained up to July 26, i.e., twenty-seven days from the time the branch was first exposed.

Experiment 4

On June 29 a Jonathan apple, shown in figure 3, covered with beads of exudate was exposed to the direct sunlight in the same location as that mentioned in Experiment 1. These beads of exudate were tested in the same way as the others and the characteristic results of fire-blight were obtained up to July 12 or fourteen days after the apple was removed from the tree. Another Jonathan apple infected in a similar way and obtained from the same bunch on the tree as the one just mentioned, was left in the laboratory. The latest date of obtaining living blight organisms from it was July 13 or fifteen days after the fruit was picked. These apples were only about half rotted when they were picked. They would thus tend to retain the moisture and probably this assisted in keeping the bacteria alive a little longer than in the withered fruit referred to in Experiment 2.

Experiment 5

On July 12 several blighted Spitzenberg branches were left in an orchard in which there was a cover-crop of alfalfa. Similar branches were placed on the ground in a clean cultivated orchard. Cultures were taken from these at intervals of two days for eighteen days and every day after that. The last living culture from the former samples was obtained August 10 or twenty-nine days after the branches were cut from the tree, and from the latter, on August 6, the organisms having held their vitality twenty-five days. This was repeated several times with about the same results, the maximum exposures from which living bacteria were obtained varying from twenty to thirty-five days.

The branches left in the alfalfa invariably showed living organisms longer than similar branches on clean-cultivated soil. This difference was usually only a day or two but occasionally it was as long as five or six days. Moreover, the branches in dense alfalfa with plenty of irrigation water showed a distinct tendency to ooze. The exudate, if hard, often became soft making it possible for insects to carry away some of the germs. In none of the other experiments was there any indication of the exudate softening or oozing.

Tests were also made by using infected terminal twigs and water-sprouts. In these cases the vitality of the organism was much shorter, seldom re-

maining active beyond the fifth day. In a few instances where the twigs were left in tall irrigated alfalfa, living organisms were found after seven days. As has been said these results correspond fairly well with those of Fulton in which the bacteria "became inactive in three to five days."

TREATMENT OF ACTIVE CANKERS

The following method of treating active cankers on large limbs has probably been tried elsewhere but as far as the writer is aware no definite account of it has been recorded. This treatment consists of shaving off the outer bark of the canker much after the fashion of the usually recommended mode of procedure for treating cankers except that the bark is not removed down to the sapwood but a thin layer of cambium is left. The same precaution is taken to get beyond the infected areas as in the usual method of treating cankers. Under these conditions, the sunlight should penetrate the remaining thin layer and destroy any living organisms. The observations on this experiment were made in two different orchards. The orchardists in charge of these two places obtained this suggestion by reading the articles by Stewart and by O'Gara. In both of these articles, statements are made concerning the destructive effect of light and heat on the fire-blight organism. The only suggestion the writer offered was the desirability of washing the wound with some disinfectant after shaving the bark off, preferably a weak solution of lysol. One of the orchardists took the suggestion, the other did not. These orchards were visited on an average of once each week during the summer. Observations and notes were made on the different trees treated. Samples of the bark were frequently tested for blight by the green-pear method previously mentioned.

In the first orchard between fifty and sixty trees mostly Comice pears were treated. The orchardist was so confident that the method would be successful that he did not use a disinfectant of any kind. He used a large jack-knife and shaved off the bark of oozing cankers without sterilizing the knife or the wound. He was always careful, however, never to allow the blade of his knife to go deeper than the shaving he was cutting off. With each stroke of the knife a whole shaving was separated from the tree. Thus, by a series of rapid strokes, portions of the bark were taken off, always leaving a portion of the cambium intact. The argument used by the orchardist for not disinfecting the tools or wounds was: "If my theory regarding the sunlight killing the organisms is correct, then those germs that are rubbed off the blade of the knife on the fresh cut surface should be killed by it as well as all the other fire-blight bacteria in the thin layer of bark that is left. There is no chance for the organism to get

into the tissue of the bark because a complete shaving is cut off with every stroke. It is, therefore, a waste of time and an additional expense to sterilize the knife and wounds after each operation." In spite of this crude method of treating the canker it was remarkable how few secondary infections were made. In forty per cent of the cankers treated in this way the blight later extended beyond the treated areas. In practically all cases new cambium was formed apparently healing over the wound. In a few instances of these latter, however, it was determined by making gross cultures that the organisms had remained alive next to the cambium layer. This was probably due to a failure to remove sufficient bark as in these cases the bark which remained was thicker than elsewhere. These few cases are likely to prove the most dangerous as they probably will develop into hold-over cankers and thus cause increased infection another year.

In the second orchard more care was taken. The cankers were carefully peeled, an effort being made in each case to cut beyond the affected area. The wounds made were well washed with a four per cent solution of crude lysol. A much weaker solution, however, would probably have done just as well. Lysol or crude creosote is preferable to corrosive sublimate because of its penetrating power. Much better results were obtained in this orchard than in the first. Even here, however, instances occurred where the blight later extended beyond the treated area. Although the cambium began to grow over practically all of these wounds yet the growth was much slower and uncertain than in the first orchard. This was probably due to the use of an injurious strength of the disinfectant.

The writer compared the results in this orchard with others in which the usually accepted mode of treatment of active cankers was practised, namely, to cut out all the infected bark down to the sapwood and to disinfect the wound. In order to insure reaching beyond the infected area the bark is removed a foot or eighteen inches beyond the apparent limits of the canker as seen in the outer bark. The proportion of successful operations in these two orchards was practically the same. Those that proved unsuccessful in both cases were usually due to a failure to cut beyond the infected area in the original canker so that the organism continued its work.

In cases where a band of the outer bark is cut below and above a canker to prevent its spreading there is no advantage over the regularly accepted method of treatment. Although either of these treatments may stop the spread of the canker, yet in the former method there is nothing done to prevent it from oozing and becoming a source of infection to other trees.

CONCLUSIONS

These experiments clearly show that the fire-blight organism (*Bacillus amylovorus*) under field conditions, at least under those found in the Yakima Valley, lives longer than has been generally supposed from work with artificial cultures. The reason for this is readily seen in the protection these organisms obtain from the bark of the tree and the hardened gelatinous envelope caused by the drying of the exudate. The process of killing is often although not always, simply that of desiccation. The larger the limbs that are cut off and the larger the beads of exudate the longer does the organism retain its vitality. In a similar way the amount of moisture surrounding the blighted branch after it is cut off determines to a large extent the length of time the organisms will live. This is especially true where the temperature is reasonably low, from 15°C. to 18°C. If blighted branches are cut off and left in a cover-crop of clover or alfalfa the protected organisms may retain their vitality a month and at the time of irrigation or rain the exudate may soften and begin to ooze, thus becoming a source of further infection. Unless the branches are thus moistened they may not exude and therefore may not be a source of infection, but it is wisest to burn the branches as soon as possible after they are cut off.

In treating active cankers by peeling the bark so that a portion of the cambium is left, there is a possibility of this mode of treatment being of some real value in attempting to save large limbs provided that only a thin layer of bark is left. It is important that the cut surface be treated with some disinfectant such as lysol or creosote, weak enough that it will not injure the cambium cells of the tree and yet having sufficient strength to kill the bacteria when it penetrates the remaining bark. A one per cent solution is probably strong enough to accomplish this purpose. More experimental work, however, should be done before it is safe to attempt anything on a large scale or to place explicit confidence in this mode of treatment. With care there probably will be no more failures than by following the usually recommended method. It has, moreover, this decided advantage that the cambium eventually grows over the whole wound, saving the limb.

In practically all the cankers treated in this way the cambium began to grow within a few weeks and by autumn many of the wounds were completely covered. Even in those cases where the blight organisms continued to grow beyond the treated area the cambium began to develop where the bark had been removed. Many of these, however, became reinfected later because the organism was still in the old bark.

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REVIEWS

The Genus Phoradendron. By William Trelease, Professor of Botany in the University of Illinois. Octavo, pp. 224, pls. 245. Published by the University. Price, paper $2.00, cloth $2.50.

The leafy mistletoes of America are a very interesting group of parasitic plants attacking trees and shrubs. These mistletoes have been studied by a number of botanists, among them Torrey and Engelmann of this country. The published results of these investigations are scattered in separate publications, a number of which are not available to many plant pathologists. Considerable confusion as to the definition and limits of the species of Phoradendron in this country has existed from the beginning. The name *Phoradendron flavescens* as currently applied to a number of forms which vary so considerably as to be specifically different illustrates the conditions as to nomenclature before the present publication appeared. The present volume has assembled the present knowledge of this group of mistletoes in a concise form, well arranged, conveniently indexed, and copiously illustrated.

The genus Phoradendron is separated into two primary subgenera: the Boreales, without cataphyls on their foliage shoots, with all but one species occurring in the United States and Mexico; and the Equatoriales with cataphyls on their foliage shoots, with all species occurring in tropical or subtropical regions.

Since all the species of Phoradendron in the United States belong to the Boreales, our forest pathologists will be primarily interested in this subgenus. The Boreales are divided into three groups, two of which have representatives in the United States: the Pauciflorae, with two pistillate flowers; and the Pluriseriales, with six or more pistillate flowers to each joint.

The Pauciflorae are separated into the Aphyllae, leafless forms, possessing only non-articulating scales; and the Bolleanae, with scale-shaped articulating leaves. Of the former 4 species (1 new), and of the latter 8 species (5 new) occur in the United States.

The Pluriseriales are separated into five divisions, one of which with leaves of moderate size is represented by 12 species (3 new) in this country.

In addition to the nine species reported from the United States, several new varieties are described. In all cases specific distinctions appear to

be based on definite characters. The writer of this review has collected many specimens of Phoradendron, chiefly from the southern, southwestern, and western United States, and has made thousands of field observations involving many of the American species. It appears to him that it may be necessary in case of a few species to make a series of inoculations in order to fully establish the relationships of forms here considered distinct. This is indicated by some of the partial results already obtained by cross inoculations recently made by the writer of two species of Phoradendron on coniferous hosts. These show that the influence of the host on the parasite may exert an effect on the habit of growth in stems of the parasite, and that at least two species ordinarily considered distinct may be only forms which vary with the species of host attacked.

GEORGE GRANT HEDGCOCK

PHYTOPATHOLOGICAL NOTES

Facultative heteroecism (?) of Peridermium harknessii and Cronartium quercus. Facultative heteroecism in these two rusts is claimed by Meinecke[1] as the result of infection and field studies. Aeciospores of *Per. harknessii* sown on *Pinus radiata* produced galls, aecia, and aeciospores typical of that rust species. These results, coupled with the assumption that *Per. harknessii* and *Per. cerebrum*, the latter having been established as heteroecious, are identical, are the foundations of this claim. *Cronartium quercus* having been found capable of overwintering in the uredinial stage in the leaves of *Quercus agrifolia* is likewise said to show facultative heteroecism.

No acceptable instance of facultative heteroecism in the rusts, so far as the writer is aware, has been known and, though such a condition cannot be considered impossible, neither of the cases cited meets the requirements which should be established for this claim. The ability of these rusts to exist in the absence of an alternate host plant is indicated, but this alone does not constitute autoecism nor facultative heteroecism.

Heteroecism in the rusts implies an alternation of generations, the gametophyte (pycnia and aecia) being developed on one host or group of hosts, and the sporophyte (uredinia and telia) on another. A species must be capable of producing both generations on the host of one generation to be considered facultatively heteroecious. The overwintering of the uredinial stage of *Cronartium quercus* on the sporophytic host is merely another instance of continuous asexual propagation. Ludwig[2] has cited a number of species which overwinter in this way, and many additional ones doubtless exist.

Granting the ability of *Per. harknessii* to reinfect its host, *Pinus* sp., is the assumption of facultative heteroecism warranted? Proof of the identity of *Per. harknessii* and *Per. cerebrum*, or of the existence of an alternate host for the former, is lacking, and though similar, they must be considered distinct, in view of Meinecke's cultures, until proven otherwise. The ability of aeciospores to reinfect the host on which they are borne should be conclusive proof of autoecism, and *Per. harknessii* should, therefore, be autoecious but not facultatively heteroecious. The true

[1] Meinecke, E. P. Peridermium harknessii and Cronartium Quercuum. Phytopath. **6**: 225–240. June, 1916.

[2] Ludwig, C. A. Continuous rust propagation without sexual reproduction. Proc. Indiana Acad. Sci. **1914**: 219–230. 1915.

character of these spores may well be questioned. Although morphologically aecidiospores, they may be aeciospores, teliospores, or urediniospores in function, since all three may be borne catenulately in aecidioid fructifications. If the inoculated spores are aeciospores, the resultant spores must be urediniospores or teliospores (aeciospores do not reproduce aeciospores); if urediniospores, the same possibilities hold; and if teliospores they must produce teliospores or aeciospores. Germination studies of the spores and perhaps cytological studies of their formation may be necessary before the exact status of this species is known.

F. D. FROMME

Relation of soil temperature to infection of flax by Fusarium lini. During the past year experimental work with flax wilt has been conducted in the pathological greenhouse at the University of Wisconsin, using soil and seed courteously furnished by Professor H. L. Bolley of North Dakota. The outcome has been a confirmation under greenhouse conditions of Bolley's conclusions as to the resistance of certain strains of flax and the susceptibility of others.

A point of further interest which has developed is the relation of soil temperature to infection. A more rapid wilting of susceptible plants was noticed in flats near the heating system. Soil temperatures were taken, and it was found that the temperature in flats near the heating pipes ran from 18° to 20°C., while the temperature in flats near the center of the greenhouse, where there was much less infection, ran from 14° to 17°C. At the opening of spring when the temperature in these flats rose above 17°C. practically all of the plants of the susceptible strain wilted. Since there was some infection below 17°C., this seemed to indicate that the critical temperature for the infection of flax by *Fusarium lini* Boll. is somewhat below this point. This was of interest since Gilman (Phytopath. **4**: 404. 1914), found that the critical temperature for infection of cabbage by *Fusarium conglutinans* Wollenw. is about 17°C.

Following these observations by the writer an attempt was made to control the soil temperature and to determine more accurately the critical temperature for infection of flax by *Fusarium lini*. By means of a water jacket around the pots the temperature was held fairly constant at the desired points. It was found that at temperatures below 15°C. no wilting of flax plants occurred, while plants in a control pot where the temperature ran from 19° to 21°C. wilted rapidly. When the temperature was held at 13° to 14°C. the flax plants grew fairly well and no indications of wilt were evident. However, when the temperature was allowed to run above 16°C. for one day or more some of the plants in each case became infected, as could be seen by the appearance of wilt symptoms within three days, even when the temperature was subsequently lowered. This

experiment was repeated with similar results. This indicates that the critical temperature for infection of flax by *Fusarium lini* is about 15°–16°C. W. H. TISDALE

Phacidium infestans on western conifers. In the spring of 1913, after the disappearance of the snow in the lateral valleys of the Pendd, Oreille River drainage in northern Idaho, the reproduction of *Abies grandis* and *Pseudotsuga taxifolia* was observed in several locations to be in a dead or dying condition. Those seedlings which had remained longest under the snow were practically all dead. An examination of the affected plants showed the needles to be uniformly attacked by a fungus which was not critically examined at the time. In July of the same year the reproduction of *Abies concolor* in certain valleys of the Whitman National Forest, Oregon, was found attacked by a fungus under conditions exactly similar to that of the grand and Douglas firs in Idaho. A study of a quantity of material from both regions showed that the needles were infected by *Phacidium infestans* Karst. This fungus is practically unknown in this country as a cause of a serious disease of forest growth, and its general characteristics should be made known.

The symptoms of the disease on our western conifers are similar to those described by Lindberg[1] and Lagerberg[2] in the northern province of Sweden. The fungus attacks only those needles which are covered by the snow. This is shown by the fact that the upper part of the crowns of young trees not covered by the snow is always free from the fungus. This gives to the general reproduction in regions where the disease is serious a very striking appearance. The infected needles remain attached to the tree and soon after the disappearance of the snow assume a brown color, which later in the season changes to an ashen gray. The apothecia of the fungus begin to appear on the under side of the needles about June, rupturing in the characteristic manner of the genus, and produce mature spores from August to October. The lobes of the apothecia eventually fall away, usually during the following year, leaving a cavity in the tissues of the needle after the manner of *Keithia thujina* Durand on Thuja. . The needles become paler in color and remain attached until broken off by wind or snow.

So far the fungus has not been discovered in any forest tree nursery, but the fact that natural reproduction succumbs very rapidly to an attack makes it a possible menace in all nurseries where firs are grown. Whether or not the fungus is confined in this country to firs is not known. No

[1] Lindberg, Fred. *Thelephora laciniata* flikig barksvamp, och *Phacidium infestans*, snoskytte, två stora skadegörare, i de norrländska plantskolorna. Skogsvårdsföreningens Tidskrift, häfte 9, 1914.

[2] Lagerberg, Torsten. Tallskytte och snöskytte. Skogen, May, 1915, p. 117–26.

collections have as yet been made on pines in this region. In the northern provinces of Sweden pines are chiefly attacked and the fungus is seriously interfering with reforestation. So far *Phacidium infestans* has been collected on the following hosts: *Abies grandis*, *A. lasiocarpa*, *A. concolor*, and *Pseudotsuga taxifolia*, and seems to occur chiefly between the fortieth and forty-fifth degrees of latitude. In Sweden the fungus is reported to occur but rarely below the sixtieth degree of latitude.

JAMES R. WEIR

Pinus ponderosa and P. jeffreyi, hosts for Razoumofskya americana. This parasite, which has only been reported on *Pinus contorta* and *P. banksiana*, has recently been found by the writer in the vicinity of Coeur d'Alene Lake, Idaho, and also at Sumpter, Ore., on *Pinus ponderosa*. In a recent letter to the writer, Mr. J. S. Boyce, of the Office of Investigations in Forest Pathology, Department of Agriculture, reports the finding of *R. americana* on *Pinus jeffreyi* in the Little Grizzly Valley, Plumas National Forest, California. The discovery of these new hosts has been expected since the common mistletoe of *Pinus ponderosa*, viz: *Razoumofskya campylopoda* (Engelm.) Piper, is occasionally found on *Pinus contorta*. Sometimes both parasites are found on the same tree of either species.

The effect of *Razoumofskya americana* Nutt. on *Pinus ponderosa* is the same as that on its other hosts. Large witches'-brooms are produced, in some cases involving the entire crown, causing serious suppression.

The host relation of these two parasites indicates that any one of the mistletoes of the hard or yellow pines may be expected to occur occasionally on any member of the group other than the species on which it is of economic importance. On the other hand, the false mistletoes (Razoumofskya) very rarely occur outside the host genus.

JAMES R. WEIR

Personals. Dr. Donald Reddick of Cornell University has been granted sabbatic leave and will spend the ensuing academic year at Johns Hopkins University where he will be engaged in special work in plant physiology. Matters pertaining to *Phytopathology* should be addressed to him at the Laboratory of Plant Physiology, University Parkway, Baltimore, Md.

Dr. A. J. Mix, assistant botanist at the New York (Geneva) Agricultural Experiment Station, has been appointed Instructor in Plant Pathology, in the Department of Botany, University of Kansas, Lawrence, Kansas.

Dr. J. L. Weimer, instructor in plant pathology, Cornell University, has been appointed assistant botanist in the Purdue University Agricultural Experiment Station, Lafayette, Ind., and has entered upon his duties in connection with the rust investigations.

LITERATURE ON AMERICAN PLANT DISEASES[1]

COMPILED BY EUNICE R. OBERLY, LIBRARIAN, BUREAU OF PLANT INDUSTRY AND FLORENCE P. SMITH, ASSISTANT

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Abbott, F. H. The red rot of conifers. Vermont Agr. Expt. Sta. Bul. 191 (Vermont Forestry Pub. 19), 20 p., 2 fig. 1915.

Trametes pini.

American Phytopathological Society, Pacific Division. Report of the Riverside meeting, December 29, 1915. Phytopathology **6,** no. 3: 307–310. June, 1916.

Blankinship, Joseph William. Conditions of plant life in the Selby smoke zone, January 1 to July 1, 1914. U. S. Dept. Int. Bur. Mines Bul. 98: 381–397, fig. 14, pl. 29–32 (col.). 1915.

Brooks, A. B. The chestnut blight and the white pine blister rust. West Virginia Dept. Agr. Bul. 12, 21 p., illus. 1916.

Endothia parasitica (chestnut blight).

Carpenter, Clarence Willard. The Rio Grande lettuce disease. Phytopathology **6,** no. 3: 303–305, 1 fig. June, 1916.

Symptoms indicate root trouble. Alkali problem sufficient to offer partial explanation of disease.

Cauthen, E. F. Wilt resistant varieties of cotton. Alabama Agr. Expt. Sta. Bul. 189: 67–88, illus. 1916.

Cook, Melville Thurston, and **Lint, H. Clay.** Potato diseases in New Jersey. New Jersey Agr. Expt. Sta. Circ. 53, 23 p., 9 fig. 1915.

Substitute for Circ. 33, now out of print.

Czarnecki, Helen L. A Gloeosporium disease of the almond probably new to America. (Abstract.) Phytopathology **6,** no. 3: 310. June, 1916.

Gloeosporium amygdalinum.

Dougherty, Paul I. Red leaf-spot of Hippeastrum. (Abstract.) Phytopathology **6,** no. 3: 309. June, 1916.

Duggar, Benjamin Minge. Rhizoctonia solani in relation to the "Mopopilz" and the "Vermehrungspilz." Ann. Missouri. Bot. Gard. **3,** no. 1: 1–10. February, 1916.

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Durst, C. E. Tomato wilt investigation in Union county. Trans. Illinois State Hort. Soc. n.s. **49** (1915): 511–514. [1915.]

Discussion, p. 514–521.

[1] This list aims to include the publications of North and South America, the West India Islands, and islands controlled by the United States, and articles by American writers appearing in foreign journals. All authors are urged to coöperate in making the list complete by sending their separates and by making corrections and additions, and especially by calling attention to meritorious articles published outside of regular journals. Reprints or correspondence should be addressed to Miss E. R. Oberly, Librarian, Bureau of Plant Industry, U. S. Dept. Agric., Washington, D. C.

Erwin, Arthur Thomas. Using potatoes infected with late blight for seed purposes. Rpt. Iowa State Hort. Soc. **50** (1915): 420–423, illus. 1916.

Gilman, Joseph C. Cabbage yellows and the relation of temperature to its occurrence. Ann. Missouri Bot. Gard. **3,** no. 1: 25–82, 21 fig., 2 pl. February, 1916.
Literature cited, p. 78–81.
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Harrison, John Burchmore, Bancroft, C. Keith, and **Bodkin, G. E.** The cultivation of limes. III. Jour. Bd. Agr. Brit. Guiana **9,** no. 3: 122–129. May, 1916.
Diseases of lime trees, p. 122–126.

Harter, Leonard Lee. Rhizoctonia and Sclerotium rolfsii on sweet potatoes. Phytopathology **6,** no. 3: 305–306. June, 1916.

——— Storage-rots of economic aroids. Jour. Agr. Research **6,** no. 15: 549–571, 1 fig., pl. 81–83. July 10, 1916.
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Hartley, Carl. Non-parasitic stem lesions on seedlings. (Abstract.) Phytopathology **6,** no. 3: 308–309. June, 1916.

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Heald, Frederick De Forest. Some new facts concerning fire blight. Better Fruit **10,** no. 11: 21–22. May, 1916.

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Bacillus amylovorus.

Jones, Fred Reuel. Pleosphaerulina on alfalfa. Phytopathology **6,** no. 3: 299–300. June, 1916.
Pleosphaerulina briosiana.

Jones, Wyatt W. The occurrence of sulphur dioxide injury to plants in the Selby smoke zone. U. S. Dept. Int. Bur. Mines Bul. 98: 398–427, pl. 33–37 (col.). 1915.

Kern, Frank Dunn, and **Orton, Clayton Roberts.** Phytophthora infestans on tomatoes. Phytopathology **6,** no. 3: 284–287, 2 fig. June, 1916.

McCubbin, W. A. Fruit tree diseases of southern Ontario. Canada Dept. Agr. Bul. 24 (s. 2), 77 p., 70 fig. 1915.

McMurran, Stockton M. Notes on pecan diseases. Amer. Nut Jour. **4,** no. 6: 81, 86, illus. June, 1916.

Manns, Thomas F. Report of committee on fungus diseases. Trans. 29th Ann. Meeting Penin. [Md.] Hort. Soc. **1916**: 58–64. 1916.

Massey, L. M. Gladiolus corm diseases. Mod. Gladiolus Grower **3,** no. 5: 70–73. May, 1916.

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Mix, A. J. The formation of parenchyma wood following winter injury to the cambium. Phytopathology **6,** no. 3: 279–283, 3 fig. June, 1916.

Morris, O. M. Apple rosette. Proc. 12th Ann. Meeting Washington State Hort. Assoc. **1915:** 69–72. 1916.

Norton, John Bitting Smith. Another poisonous Claviceps. Science n. s. **43,** no. 1121: 894–895. June 23, 1916.

Nowell, William. Pine-apple wilt. Agr. News [Barbados] **15,** no. 367: 174–175. May 20, 1916.

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Orton, Clayton Roberts. The diseases of the potato. Pennsylvania Agr. Expt. Sta. Bul. 140, 37 p., 23 fig. 1916.

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Stevens, Neil Everett. Pathological histology of strawberries affected by species of Botrytis and Rhizopus. Jour. Agr. Research **6**, no. 10: 361–366, pl. 49–50. June 5, 1916.

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[PHYTOPATHOLOGY, for August, 1916 (4: 321–389, Pls. IX–XIII) was issued September 12, 1916.